SnT 2025
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Infrasound Analysis of the 6 February 2023 Kahramanmaraş Earthquakes Using CTBTO Arrays

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INTRODUCTION AND MAIN RESULTS

This presentation provides a summary of the Infrasound analysis created using IMS data and the DTK-PMCC program developed by IMS for the major earthquakes that occurred in Türkiye on February 6, 2023.

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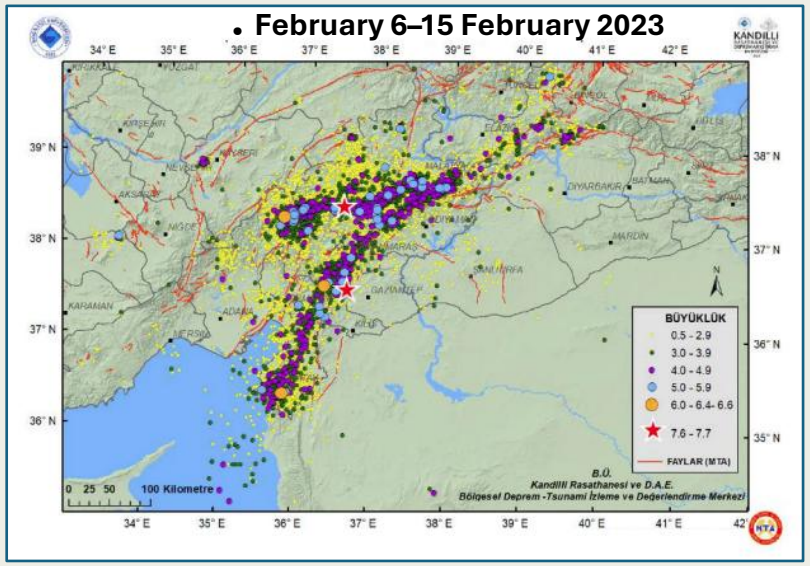
Introduction

On February 6, 2023, at 01:17 UTC and 10:24 UTC, two devastating earthquakes with magnitudes of Mw 7.7 and Mw 7.6 struck, with epicenters located in Pazarcık (Kahramanmaraş) and Elbistan (Kahramanmaraş), respectively. These earthquake couples are one of the most destructive earthquakes occurred in recent history affecting 11 provinces in Turkey's Southeast region and causing more than 53000 casualties in Türkiye. Earthquakes cause a total rupture length of 300 km along the East Anatolian Fault Zone. These two main events were also recorded by infrasound stations of the International Monitoring System (IMS) under the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), at distances ranging between 2000–3000 kilometers. The analysis of these events was conducted with the DTK-GPMCC and Geotool applications of NDC in a box software suite developed by the Provisional Technical Secretariat (PTS) for use at National Data Centers (NDCs).

Rupture occurring in the surface

Before – after in Hatay city center.



The epicenter distributions of the earthquakes that occurred

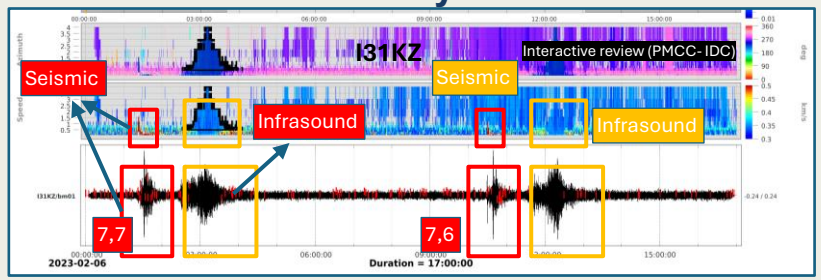
Data

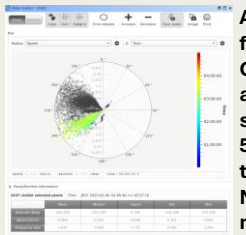
The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) plays an important role in detecting such events through its International Monitoring System (IMS) for infrasound. The data used in this study were obtained from IMS infrasound stations (I26DE, I48TN, I31KZ, I43RU, I19DJ). This network consists of 60 infrasound stations spread across the globe. The dataset was imported into the Geotool software using the VDMS system.

Methods

Progressive multi-channel correlation (PMCC) is a set of processing methods used to detect a consistent wavefront passing through a series of sensors and to estimate propagation parameters, namely the direction and speed of propagation (Shearer, 1999). PMCC is used in the detection of seismic and infrasonic events (Cansi, 1995; Cansi and Klinger, 1997; Cansi et al., 2008; Brachet et al., 2010). In this study, data released by IMS were analyzed using the DTK-GPMCC program. As a result of the analysis, the infrasound traces of the earthquakes were searched for, and infrasound interpretations related to the earthquakes were made using the azimuth, velocity, and frequency information obtained from the records.

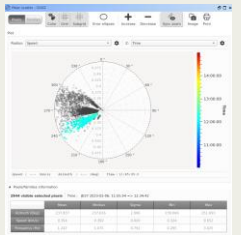
Analysis





Pazarcik M: 7,7

As seen in the polar graph, for the first earthquake (Pazarcik Mw: 7.7), Celerity = 0.310 - 0.35 m/s, azimuths and = 169-170 deg, while the seismic velocity varies between 5.7-9.1 m/s. On the other hand, for the second earthquake (Elbistan Mw: 7.5), Celertiy = 0.330 - 0.355 m/s, azimuths = 169-170 deg, and seismic velocity V = 5.7-9.1 km/s.



Elbistan M: 7,6

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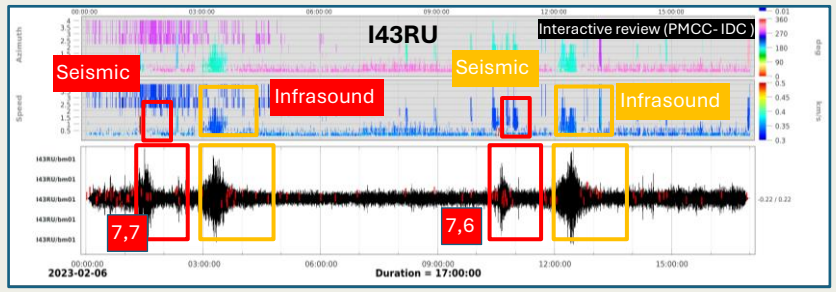
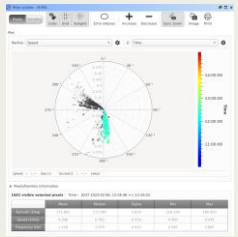
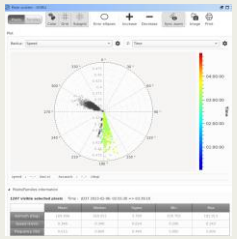
Analysis





As seen in the polar graph, for the first earthquake (Pazarcik Mw: 7.7), Celerity = 0.318 - 0.352 m/s, azimuths = 169-170 deg, while the seismic velocity varies between 5.7-9.1 km/s. On the other hand, for the second earthquake (Elbistan Mw: 7.5), Celerity = 0.330 - 0.355 m/s, azimuths = 169-170 deg, and seismic velocity V = 5.7-9.1 km/s.

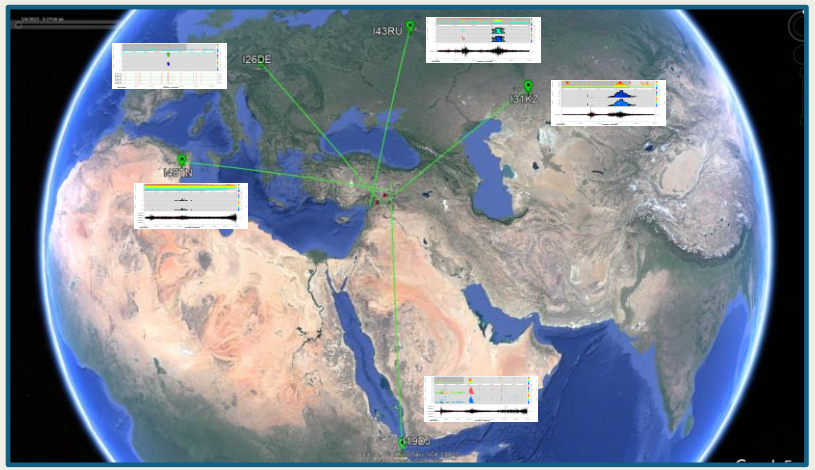


Pazarcik M: 7,7

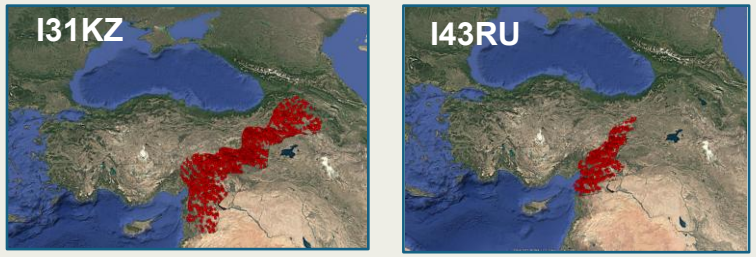
Elbistan M: 7,6

The analysis using data obtained from the I43RU and I31KZ stations of the IMS for Kahramanmaraş earthquakes were done using IDC configuration in PMCC. The signals were passed through a filter with a bandwidth of 0.05-0.5 Hz. A beam was then created for analysis. Based on the results obtained, the relationship between the azimuth and velocity values of the signals and the earthquake was examined. As can be seen in above figure, not only infrasound signals but also seismic signals could be easily identified.

Results



Location of the Pazarcik Earthquake estimated from five IMS infrasound stations



Seismic-acoustic coupling distribution created at stations by GTK-PMCC

Pazarcık-Kahramanmaraş 7.7 - Time : 01:17:33:410 (IDC)								
	IDC/REB				KOERI			
Sta	Dist	Phase	Time	Azim	Phase	Time	Azim	Celerity/Speed
I19DJ	26.26	I	03:56:50	351.4	I	03:51:50	353	0,349
I26DE	20.54	I	03:35:47	106.5	I	03:20:32	114	0,332
I31KZ	19.93	I	02:26:51	227.8	I	02:37:11	235,7	0,353
		p	01:22:12		p	01:22:45		8,32
I43RU	19.46	I	02:56:03	169.4	I	02:55:10	168,2	0,347
		p	01:21:58		p	01:22:41		9,46
I48TN	22.33	I	03:51:47	72.3	I	04:01:12	76	0,378
Elbistan-KahramanMaraş 7.6 - Time : 10:35:57:030 (IDC)								
	Theoretical arrivals from PMCC				KOERI			
Sta	Dist	Phase	Time	Azim	Phase	Time	Azim	Celerity/Speed
I31KZ	19.93	I	12:32:15	236	I	12:19:10	238	0,358
I43RU	19.46	I	12:31:15	179	I	12:22:11	171	0,348

Comparison of IDC and KOERI results

The table compares the analysis results of the 7.7 and 7.6 magnitude earthquakes with the IMS-REB results. For the first earthquake, both infrasonic and seismic signal azimuth and phase values could be read from five stations, and the IDC results are quite close to the results of our study. On the other hand, while IDC could not detect any infrasonic phases for the second earthquake, our study detected very distinct infrasonic phases from two IMS stations (I43RU, I31KZ). The arrival times obtained from theoretical GTK-PMCC-Diaz are compared in the table.

Conclusions

The earthquakes on February 6, 2023, were detected using DTK-PMCC analysis, both infrasound and seismic phases were confirmed, and IMS infrasound data was shown to support seismology. These results highlight the importance of the IMS network for infrasound and earthquake monitoring assessment.